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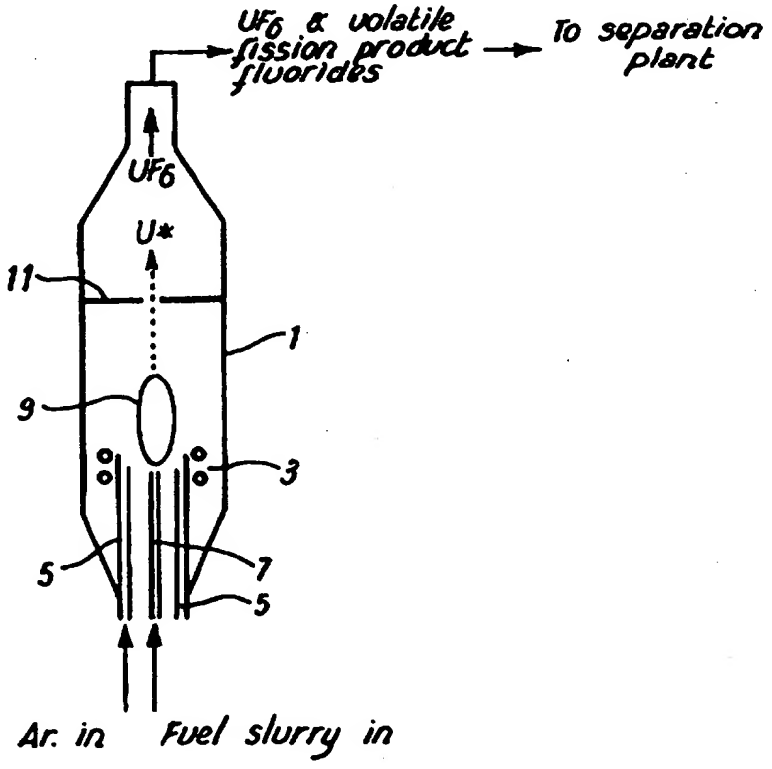
(57) Abstract

In the reprocessing of irradiated nuclear fuel, fluorination of the fuel is carried out by feeding the fuel to an ionised gas plasma and then contacting the resultant excited species with a fluorinating agent, for example, fluorine, so as to effect fluorination. The ionised gas plasma is an inductively-coupled plasma or a microwave plasma, and the fuel is fed to the plasma in the form of a slurry or a powder fluidised by a gas. Where the slurry is formed from LWR fuel, a variety of volatile and involatile fission product fluorides and actinide fluorides is produced, so enabling the separation of UF_6 from the involatile fission product fluorides.



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FLUORINATION

This invention relates to fluorination and in particular to the fluorination of irradiated fuel in nuclear fuel reprocessing.

Plant size contributes significantly to the cost of a facility for reprocessing irradiated nuclear fuel. For any process, if one or more of the process stages can be carried out in smaller apparatus and at increased rate, this is likely to lead to considerable cost savings, provided overall throughput is not compromised.

Fluoride volatility reprocessing involves fluorination of irradiated fuel and the subsequent separation of fission product fluorides and actinide fluorides from UF_6. Fluorination is currently carried out using a fluidised bed to nullify the effect of the highly exothermic fluorination reaction. A large vessel is required and a large volume of highly contaminated fluid bed material is produced, which material ultimately has to be treated and disposed of. Fluorination of all the UO_2 or U_3O_8 and fission products and actinides takes approximately one day per fuel assembly. Accordingly the throughput per fluid bed is limited.

According to the present invention there is provided a fluoride volatility reprocessing procedure in the reprocessing of irradiated nuclear fuel wherein fluorination of the fuel is carried out by feeding the fuel to an ionised gas plasma and contacting the resultant excited species with a fluorinating agent whereby fluorination is affected.

The ionised gas plasma provides a source of intense heat and avoids the need for a fluid bed, allowing the fluorination reaction to be speeded up.

The ionised gas plasma may be, for instance, an inductively-coupled plasma (ICP) or a microwave plasma. In other embodiments of the present invention regions of intense heat may be created by means of a laser or by the use of infra-red light. Reference will be made hereinafter to ICPs but it should be understood that this is by way of example only.

ICPs are commonly used in analytical chemistry for the determination of concentrations of metals in solution. They provide a small and intense source of heat (temperatures up to 10,000 K are routinely achievable) and thus break down all known material to elements and ions. The plasma is created by the application of a radio frequency (rf) field, through a cooled induction coil, to an inert gas such as argon or nitrogen. The gas is ionised and the ions and electrons produced interact with the fluctuating magnetic field produced by the induction coil. Ohmic heating occurs as a consequence of resistance to movement of the ions and electrons and causes the high temperature.

Normally, in analytical applications, solutions containing the species to be analysed are sprayed into the centre of the plasma as an aerosol. In the case of the present invention, however, it has been found possible very efficiently to introduce solids in the form of a slurry into the plasma. A 100% conversion of solids to atoms and ions is readily achievable. Alternatively, a powder fluidised by an inert gas could be supplied to the plasma.

A feedstock of UO_2 and/or U_3O_8 in slurry form when fed to an ICP results in the formation of excited U atoms (U*). These excited atoms react with a fluorinating (or chlorinating) agent to produce volatile uranium species, such as UF_6.

In the case where the slurry is formed from irradiated LWR fuel, a variety of volatile and involatile fission product fluorides and actinide fluorides is produced, thereby enabling the separation of UF_6 from the involatile fission product fluorides.

The process of the present invention produces relatively little waste (no bed material waste in contrast of the fluidised-bed process) and the plant volume requirements are small. Furthermore, the process provides rapid chemical conversion of oxide fuel and fission products into separable species. An additional benefit is that the constituent parts of the apparatus are small in size and therefore readily disposable.

The accompanying drawing shows, diagrammatically, apparatus of use in the present invention. The apparatus includes a vessel 1 within which is located an induction coil 3 to the interior of which an inert gas such as argon is fed via tubes 5. Between tubes 5 is located a further tube 7

by which fuel slurry may be fed to a central position within the induction coil. Application of a radio frequency field to the induction coil (which is cooled) results in the formation of an ICP 9, into which the fuel slurry is fed. This results in the formation of excited U atoms (U*) which pass through an orifice in plate 11 to an upper region of vessel 1 which comprises a fluorinating atmosphere. This atmosphere is typically fluorine gas but may also be provided by another fluorinating agent including a novel reagent such as XeF_2, KrF_2, O_2F_2, HF, BrF_3 or BrF_5. The UF_6 and other volatile fission products produced by the reaction then pass into a storage tank and ultimately into the plant designed for separation of the fission product fluorides and the actinide fluorides.

CLAIMS

1. A fluoride volatility reprocessing procedure in the reprocessing of irradiated nuclear fuel wherein the fluorination of the fuel is carried out by feeding the fuel to an ionised gas plasma and contacting the resultant excited fuel with a fluorinating agent whereby fluorination is effected.

2. A procedure according to Claim 1 wherein the ionised gas plasma is an ICP or a microwave plasma.

3. A procedure according to Claim 1 or Claim 2 wherein the fuel is fed to the ionised gas plasma in the form of a slurry or a powder fluidised by a gas.

4. A procedure according to any of the preceding claims wherein the fluorinating agent is fluorine.

5. A procedure according to any of the preceding claims wherein the fuel is irradiated LWR fuel.

6. A fluoride volatility reprocessing procedure in the reprocessing of irradiated nuclear fuel substantially as described herein.

7. A procedure according to Claim 1 and substantially as described with reference to the accompanying drawing.

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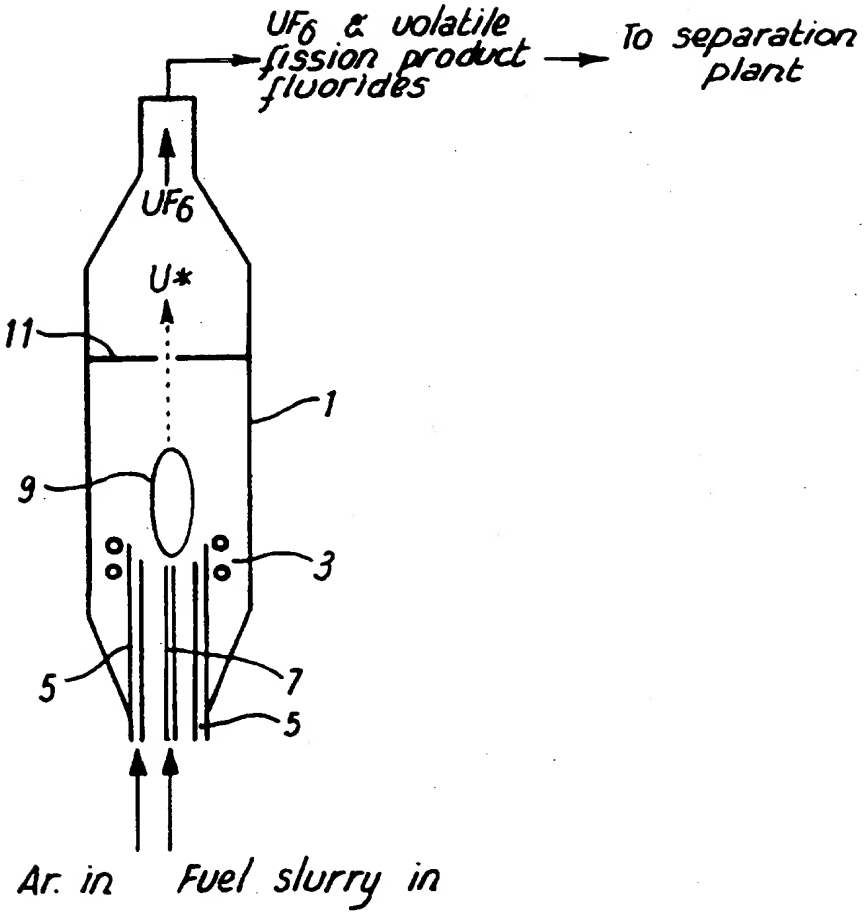

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 97/00198

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G21C19/48 C22B60/02 C01G43/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G21C C22B C01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 462 256 A (UNITED STATES ATOMIC ENERGY COMMISSION) 16 December 1966 see the whole document ---	1
A	GB 1 158 287 A (CENTRE D'ÉTUDES DE L'ÉNERGIE NUCLÉAIRE) 16 July 1969 see the whole document -----	1

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☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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